

Assessment and Installation of Electrical Systems of a Classroom Building in a Public Secondary School in Sta. Rita, Pampanga

A. Tolentino^{1*}, J.L. Salalila², H. Gutierrez³, C.J. Nucup⁴, J.E.N. Parungao⁵ & Q.E. Tantamco⁶

¹Assistant Professor, ²⁻⁶UG Scholar, ¹⁻⁶Department of Electrical Engineering, Don Honorio Ventura State University, Philippines.
Corresponding Author (A. Tolentino) Email: actolentino@dhvsu.edu.ph*



DOI: <https://doi.org/10.38177/ajast.2025.9302>

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Article Received: 07 May 2025

Article Accepted: 19 July 2025

Article Published: 23 July 2025

ABSTRACT

The Philippine Electrical Code (PEC) is a collection of rules and regulations that regulate the safe and correct construction, operation, and maintenance of electrical systems across the Philippines. Becuran National High School currently has problems regarding the population of students, hence the need for new buildings to be built. But there are some neglected buildings not currently used today due to erosion of ceilings and mainly the lack of electrical supply and faulty outlets in the classrooms. This study aims to assess and install an improved electrical system in a public secondary school in Sta. Rita, Pampanga. The initial assessment revealed multiple issues, including faulty wiring, nonfunctional lighting, burned-out outlets, and damaged ceiling fans all of which posed safety risks. Thus, a new electrical system was designed that adhered to the Philippine Electrical Code (PEC). The redesign included a modern lighting layout, upgraded power outlets, and removed branching. The installation phase successfully replaced defective components, installed lighting, and provided sufficient electrical outlets. The study succeeded in converting a faulty and malfunctioning electrical system into a code-compliant and modern system that meets the classroom's present and future requirements.

Keywords: PEC; Code; Installation; Assessment; System; Electricity; Redesign; Neglected; Faulty Wiring; Non-Functional Lighting.

1. Introduction

As studied by Hilutin, G.V. & Lunas, A.M. (2023), electricity is a critical component of modern society, powering various processes, including academic institutions. Fueled by the necessity of advancement, the Bicol University - Legazpi East Campus has undergone significant infrastructure improvements in the past decade, leading to a higher demand for electricity [11]. Protecting people and property requires an understanding of electrical risks and the application of safety precautions. Thus, this study looked into electrical risks in homes and the precautions people in Sokode-Etoe, Ghana, take. Although participants were highly aware of electrical threats, they showed a poorer understanding of safety precautions, proper emergency protocols, and the infrequent testing of wiring systems (Frank Kulor, 2024) [6].

1.1. Study Objectives

The following objectives were sought:

1. To evaluate the current state of electrical systems in the Classroom in terms of wiring condition, supply of power, and safety standards;
2. To identify specific areas within the electrical systems that require upgrades or repairs to meet the Philippine Electrical Code standards;
3. To develop comprehensive electrical design plans that address the identified issues, ensuring compatibility with the infrastructure and improving safety and performance;
4. To propose the most suitable electrical design that prioritizes safety in the classroom;
5. To implement the most suitable layout that prioritizes safety, cost-effectiveness, and efficiency in the classroom.

2. Philippine Electrical Code (PEC)

This collection of rules and regulations that regulate the safe and correct construction, operation, and maintenance of electrical systems across the Philippines is called the Philippine Electrical Code (PEC) [10]. It specifies rules for electrical design, wiring, equipment selection, grounding, protection, and other associated issues to assure electrical safety and efficiency [5]. Compliance therewith and proper maintenance will result in an installation that is essentially free from hazard but not necessarily efficient, convenient, or adequate for good service or future expansion of electrical use [4].

2.1. Electricity in Education

Electrical systems in an educational institution, especially either public or private, are crucial nowadays. Teaching methods in modern times use electricity as a means of teaching using such as projectors, televisions, and laptops [1]. With the growth in student population, the evolving needs of modern educational tools and the increased demand of energy, the current electrical system may be facing challenges related to capacity, safety, and reliability.

2.2. Becuran High School

Becuran High School (BHS), now known as Becuran National High School (BNHS), which started on July 13, 2023 was founded and established in 1966 in Philippines.

It has a student population of more than 2,500, not including the staff and faculty members. With a total area of approximately 12,300m² or 132,396 ft², which has around 15(fifteen) buildings inside the campus. With the increasing student population over the years, the number of buildings is becoming insufficient and cannot cater to every learner all at once.

Becuran National High School has four major types of education for students, namely Science Class, Regular Class, Special Program for Journalism, and Special Program for Sports. Junior High School education consists of the four major types: Science Class (sci-class), Regular Class, Special Program for Journalism (SPJ), and Special Program for Sports (SPS). Meanwhile, Senior High School education consists of all of its strands, namely: Science Technology Engineering and Mathematics (STEM), Humanities and Social Sciences (HUMMS), Accountancy Business and Management (ABM), Technical Vocational Livelihood (TVL) and General Academic Strand (GAS).

For the Junior High School level, the student population reaches up to a total of 1885 students, both males and females, to both Regular Class and Science Class, starting from Grade 7 to Grade 10.

Becuran National High School has a four-strand system in their Grade 11 Senior High School programs which are the ABM, HUMSS, STEM, and TVL strand. The total population of grade 11 students in BHNS is 374 students.

More so, Becuran National High School has a five-strand system in its grade 12 senior high school. The ABM, HUMSS, STEM, GAS, and TVL strand. With the total population of grade 12 students in BHNS reaching 339.

Therefore, the total population of the Senior High School Level department is 713 students, consisting of all the strands from Grade 11 up to Grade 12. Additionally, the teaching and non-teaching of BNHS consists of a total of 111 people, including the Principal.

2.3. Over-Population

Becuran National High School currently has problems regarding the population of students; hence the need for new buildings to be built is also a top concern. There are some neglected buildings not currently used today due to erosion of ceilings, and mainly the lack of electrical supply to the classrooms. These classrooms are unoccupied because they have not yet been repaired by the utility personnel.

2.4. Solution to Over-Population

Becuran National High School has an old way of dealing with the large number of students and is still being utilized to this day. With the number of students still increasing these past years, their solution still has not changed; the solution using the “Day and Afternoon Shifting” of students to properly regulate the number of people inside the campus and not overload the usage of classrooms.

2.5. The Target Classroom

At Becuran National High School, the current electrical systems play a central role in the operation of various school functions. However, it has become necessary to assess the existing setup to identify potential weaknesses and assess whether it is capable of meeting the growing needs of the school.

One classroom in particular is given to the researchers, which is the old Pinatubo room, naming them as F. Bacon - A. Bonifacio. It is a shabby room with improper wiring outlets and no electricity to power the room. This room is where the athletes stay and rest, and it is where their equipment is stored.

3. Motivation

The researchers observed that the electrical systems under investigation do not comply with the Philippine electrical code. The design and installation of these systems are substandard and utility personnel often resort to makeshift solutions, such as using extension cords, even for appliances like televisions. This improper setup indicates significant issues in safety, compliance, and overall system integrity.

As stated by the principal of the school, they experienced exploding transformers near the school, the reason being is overloading. The BNHS was primarily supposed to have its sole use of a dedicated transformer; it was thought to be sole-use for the school. However, due to the misunderstanding, more establishments are being connected to the transformer, which has caused overloading.

The room is not electrified even though it is served by the building's sole panel board. The lighting circuit does not function because of missing light bulbs, missing receptacles, exposed hall wiring, and absent light switches. Power receptacles are burned, missing, or inoperable, and flexible hose serves as conduits for the underground power configuration which is not ideal. Extension cords tap power from the light circuit through inadmissible octopus wiring. Also, the two fans that are installed on the lighting structure have melted plastic on the motor components, most likely due to electrical inefficiencies and mechanical factors like dust buildup, rust, and wear and tear. The electrical wiring in the building is what others might call a low-cost installation, due to budget concerns of the electricians, wirings keep extending outwards which results in octopus wiring all whilst connected to the Lighting Layout Circuit breaker, which can possibly cause overloading for the wires.

4. Methods

The IPO diagram contains all of the particulars of the procedure itself, the information and supplies needed for the operation, and explanations of every product and by-product that are based on the actual procedure.

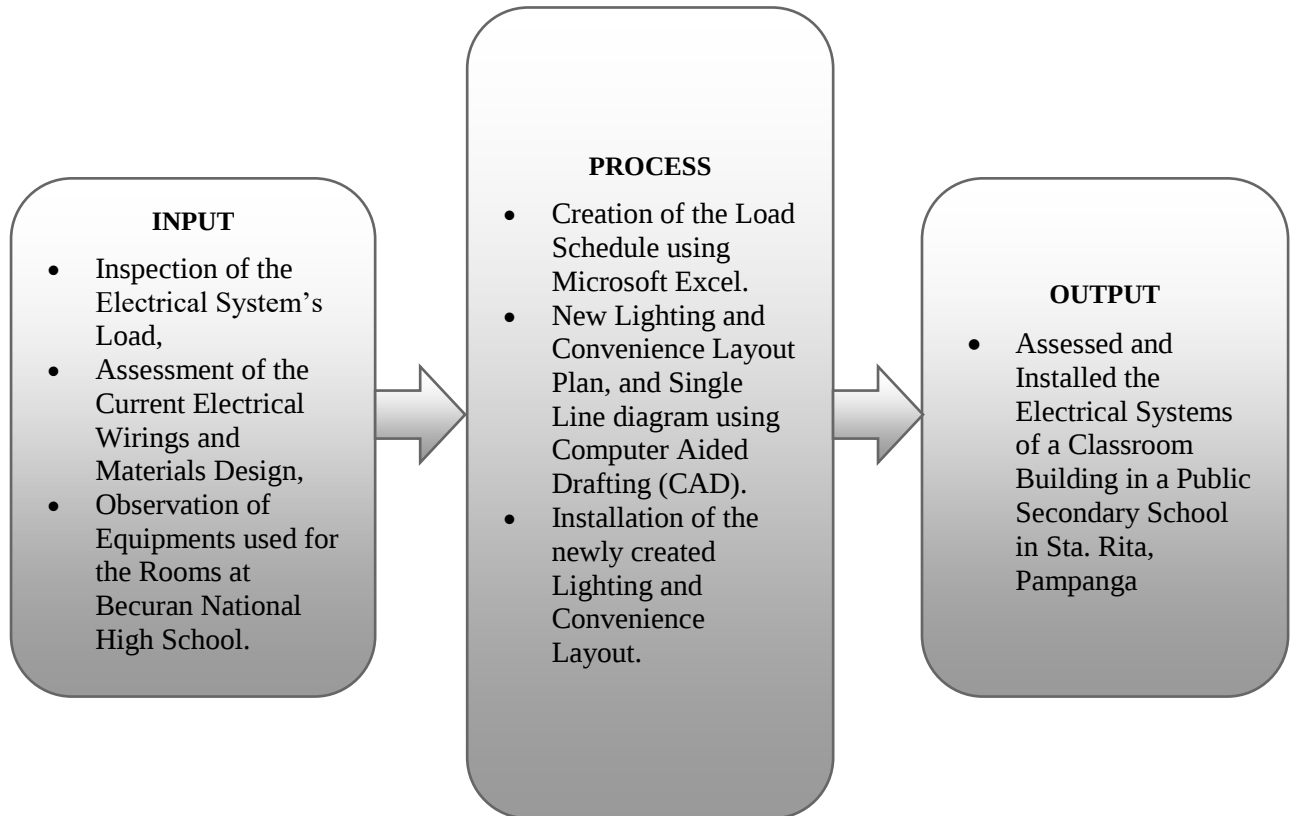


Figure 1. Paradigm of the Study

The input has insight into the current electrical wiring design and electrical materials design of the rooms. Inspection was the main goal in this part. The information and data gathered were used for the process. A table of items are listed that do not comply with the Philippine Electrical Code, measuring of dimensions, assessing of the current electrical layout, creation of a load schedule using Microsoft Excel, making the new lighting layout, power layout and single line diagram using Computer-Aided Drafting software (CAD). Lastly, the output revealed the expected results of the Assessment and Installation of Electrical Systems of a Classroom Building in a Public Secondary School in Sta. Rita, Pampanga.

The Methods section of a research paper is like a blueprint directing to the substance of the research, guiding the readers to understand how the study was conducted. It also contains the essential details on the developments, theoretical, designs, experiments, testing, and analyses of the study and helps the other researchers to understand the study better. The manuscript may comprise text, equations, symbols, figures, tables, line drawings, and photographs.

4.1. Research Design

Qualitative research methods include data collection methods such as interviews, observations, focus groups, and document analysis that enables researchers to get extensive, descriptive data about participants' viewpoints,

experiences, and surroundings. Quantitative research is the collection and analysis of numerical data. It may be used to identify patterns and trends, make forecasts, evaluate causal linkages, and extrapolate findings to larger groups. Mixed Method is the mixture of Qualitative and Quantitative research methods, this method is used, this way all evaluations are looked at effectively.

This type is aimed to find an answer to the objectives of the study to gather information for the new installation of electrical systems. It measures the professionals' evaluation of the specified room and to identify the level of satisfaction with the new electrical system. An "Inspection, Reference, Observation and Actions" Table was used as a tool to gather data about the PEC based on the electrical system safety of the room [8].

4.2. Research Locale

The study was conducted at Becuran National High School, located in Zone 1, Becuran, Sta. Rita, Pampanga. The School has a total area of approximately 12,300m² or 132,396 ft², which has around 15 (fifteen) buildings inside the campus.

It has a total student population of 2,598 to both Junior and Senior High School, not including the staff and faculty members. The one classroom used is the room, naming F. Bacon - A. Bonifacio. Given the rising problem of student-to-classroom ratio, as well as substandard application of electrical wiring, the chosen classroom building was the perfect site for the assessment and installation of PEC standard in electrical design.

The research was assessed, reviewed, proposed, and installed as a solution to meet the pragmatic needs of the school and beyond in similar circumstances.

4.3. Research Instrumentation

The research instrument used in the study was through interviews with personnel, an assessment of the specified room, and an observational approach. Data from the study were gathered using an observational approach and with the use of checklists.

4.4. Data Gathering Procedure

The research instrument used in the study was through interviews with personnel, an assessment of the specified room, and an observational approach. Data from the study were gathered using an observational approach and with the use of checklists.

5. Results and Discussion

The general layout of the building consists of 2 Classrooms, having dimensions of 6 x 9 meters, each having 2 entrances and 4 windows.

Figure 2 shows that there are no proper lighting systems and no switches for the lighting, they were completely damaged and nonfunctional. New lighting fixtures and corresponding switches were designed based on the needs of the space and then installed to restore proper lighting and ensure user convenience. Light switches were placed above 4 feet from the floor.

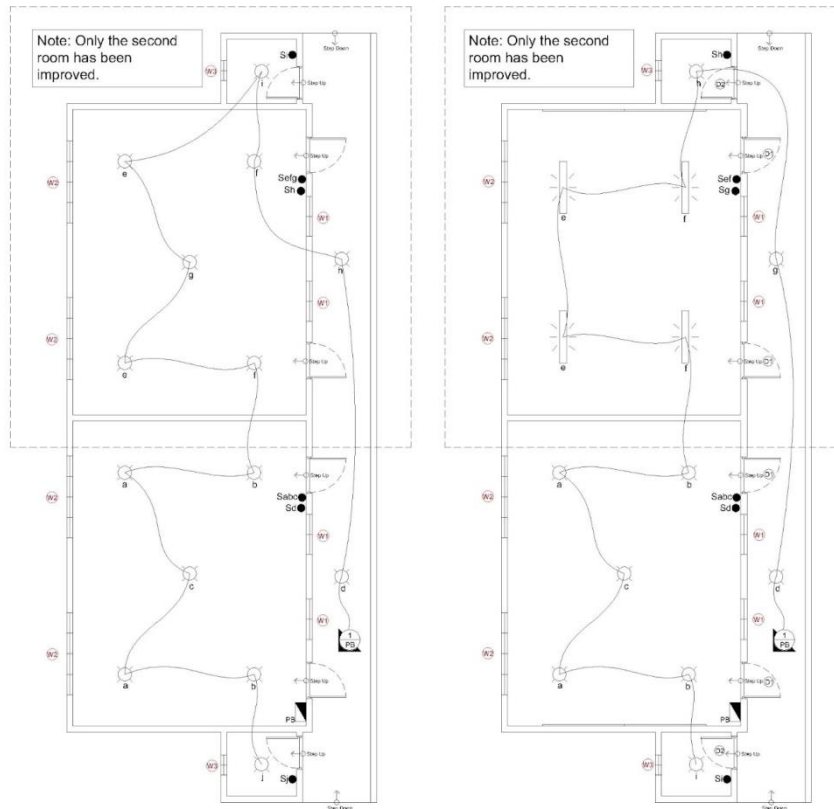


Figure 2. Old and New Lighting Layout

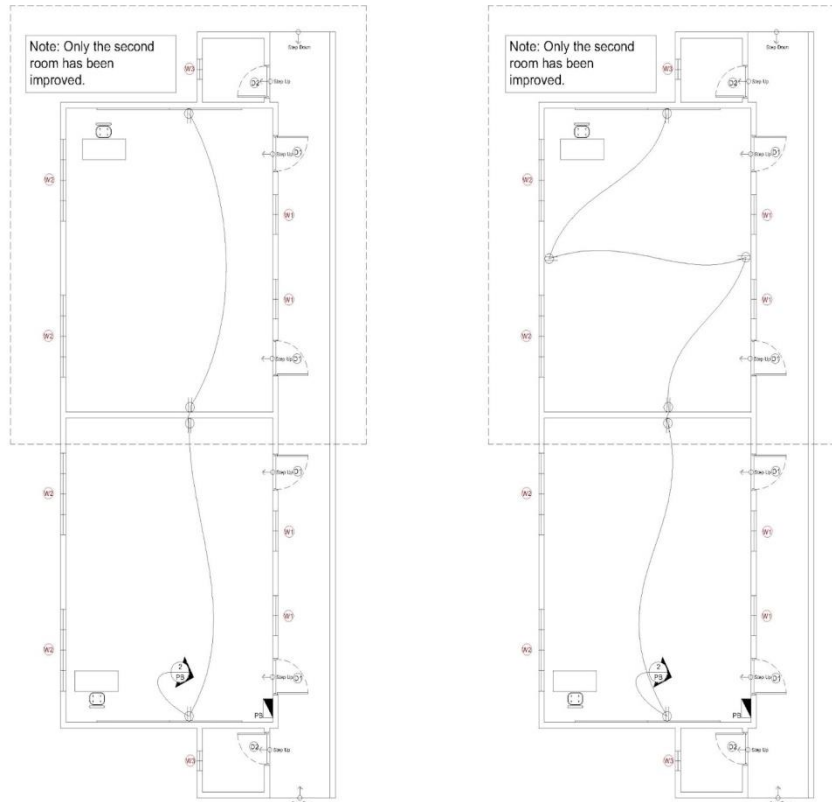


Figure 3. Old and New Power Layout

Figure 3 displays that all convenience outlets are designed and installed underground, and all are burned. The branching electrical wiring was poorly installed and characterized by hazardous octopus connections. Therefore,

the old wiring system was completely removed, and a newly designed electrical wiring system was installed in compliance with the Philippine Electrical Code (PEC) to ensure safety, reliability, and proper load distribution. The old underground wiring of the Convenience outlets was left alone and installed the newly designed Convenience layout was installed, the added outlets are also placed at least 300mm from the floor.

The ceiling fans were found to be burned out and beyond repair. Consequently, the ceiling fans were removed, and new wall outlets were installed to accommodate the use of wall-mounted fans, improving both accessibility and ventilation within the space.

5.1. Calculation for Load Schedule

With the quantity of electrical equipment like Lighting Layout and Power Layout given, a Load Schedule is made to comply with the standard electrical equipment to be used. The Following are the formula for computing the Main Circuit Breaker Ampere and Determining the sizes of wires, circuit breakers, conduits and grounding wires.

(a) Lighting Outlet Current Rating

$$I = \frac{(\text{Number of Lighting Outlets} \times \text{Rated Watts of LEDs})}{\text{Rated Voltage}} \quad \dots (1)$$

$$I = \frac{(13 \times 50w)}{230V}$$

$$I = 2.83 \text{ Amperes}$$

(b) Convenience Outlet Current Rating

$$I = \frac{(\text{Number of Convenience Outlets} \times 180 \text{ Watts})}{\text{Rated Voltage}} \quad \dots (2)$$

$$I = \frac{(6 \times 180w)}{230V}$$

$$I = 4.70 \text{ Amperes}$$

(c) Spare Stub Up in Rating (2)

$$I = \frac{(\text{Number of Convenience Outlets} \times 1500 \text{ Watts})}{\text{Rated Voltage}} \quad \dots (3)$$

$$I = \frac{(2 \times 1500w)}{230V}$$

$$I = 6.52 \text{ Amperes} \times 2$$

(d) Total Amperes Load

$$\text{Total Ampere Load} = \Sigma I \quad \dots (4)$$

$$\text{Total Ampere Load} = I(\text{lighting}) + I(\text{convenience}) + I(\text{Spare})(2)$$

$$\text{Total Ampere Load} = 2.83 \text{ A} + 4.70 \text{ A} + (6.52 \text{ A})(2)$$

$$\text{Total Ampere Load} = 20.57 \text{ Amperes}$$

(e) Wire Current Rating

$$I_w = (\text{Total Amperes Load} \times \text{Demand Factor}) + (0.25 \times \text{Largest Motor Load}) \quad \dots (5)$$

$$I_w = (20.57 \times 0.8) + (0.25 \times 4.7)$$

$$I_w = (20.57 \times 0.8) + (0.25 \times 5)$$

$$I_w = 16.45 + 1.17$$

$$I_w = 17.63 \text{ Amperes}$$

(f) Main Circuit Breaker Current Rating

$$I_w = (\text{Total Amperes Load} \times \text{Demand Factor}) + (1.5 \times \text{Largest Motor Load}) \quad \dots (6)$$

$$I_w = (20.57 \times 0.8) + (1.25 \times 4.7)$$

$$I_w = (20.57 \times 0.8) + (1.25 \times 5)$$

$$I_w = 16.45 + 7.04$$

$$I_w = 23.50 \text{ Amperes}$$

This following above shows the Calculations of the Load Schedule of the classroom's Electrical Plan, Lighting Layout consists a total of 13 components, meanwhile the Convenience Layout has a total of 6 components and two Spares are also factored, therefore the currents ratings are totalled to 23.50 Amperes, which falls under the 40AT/50AF Circuit Breakers. Size of Wires also depended on the Circuit Breakers used.

5.2. Inspection, Reference, Observation and Actions

The tables below detail the norms and standards for enhancing electrical wire system design as outlined in the Philippine Electrical Code.

Table 1. Inspection, Reference, Observation and Actions

Inspection Activities	PEC Reference	Observation	Actions
Electricity of the Room	-Table 2.10.2.4(B)(2)	-No working electrical system on the room	-Installed the new Lighting Layout and new Convenience Layout from the approved electrical plan to service entrance.
Convenience Design	-Table 3.10.2.6(B)(16)	-Underground wiring for the electrical outlet -burned out outlets	-Left the old underground wiring of the Convenience outlets and installed the newly designed Convenience layout. -the added outlets are also placed at least 300mm from the floor.
Lighting Design	-Table 3.10.2.6(B)(16) -Table 2.20.2.3	-No proper lighting system and no switches for the lighting	-Installed new light switches and lighting. -light switches were placed above 4 feet from the floor.

Ceiling Fan	-Table 4.30.14.2	-Burned out Ceiling Fans	-Removed the two Burned ceiling fans and the tapped electrical wiring in the ceiling and created outlets for wall fan.
Electrical Wiring	-Table 3.10.2.6(B)(16) -2.10.1.7	-Electrical wiring above the ceiling is poorly installed -Extension cords are connected in an octopus wiring which results in branching circuits.	-Removed the old Electrical wiring from the ceiling and replaced with the new electrical wiring following the code. -Removed the old exposed octopus wired extension cords and installed new outlets per wall.

6. Advantages

This research helped solve electrical supply problems in BNHS that may cause disruptions and pose risks to students. With this, the research has enhanced safety by reducing the risk of outdated electrical systems and providing a power supply. It can further design better learning environments by using technology that does not experience interruptions from students or teachers.

The upgraded system in the room met the needs of the students and teachers by providing adequate lighting and convenient power access.

7. Conclusion

- The study successfully evaluated the state of the electrical system in the classroom, identifying significant deficiencies such as bad wiring, burned outlets, broken lights, and malfunctioning ceiling fans.
- The study improved the lighting layout, convenience outlet design, branching, and circuit protection which led to a safer and more functional system; thus, ensured compliance with the PEC.
- The redesigned system was successfully installed, replacing the damaged wiring, upgrading the circuit breakers, installing new lighting and outlets, and preparing outlets for wall-mounted fans.
- The upgraded system in the room met the needs of the students and teachers by providing adequate lighting and convenient power access.

Overall, the study succeeded in converting a faulty and malfunctioning electrical system into a code-compliant and modern system that meets the classroom's present and future requirements.

8. Future Suggestions

The following recommendations are given:

- For Becuran National High School, conduct regular inspection and maintenance of electrical systems to prevent future damage and extend similar electrical and upgrades to other unused or neglected classrooms to maximize campus resources.
- For the Faculty and Staff, avoid the use of extension cords as permanent solutions and report any electrical issues immediately and attend basic training on electrical safety awareness to better understand the risks and responsibilities involved in classroom setups.

- For the Local Government and Stakeholders, support public schools in infrastructure improvement projects, especially in upgrading outdated electrical systems that may put students at risk.
- For Future Researchers, expand the scope to assess and install PEC-standard electrical systems in other neglected classrooms within BNHS or other nearby schools and include energy efficiency analysis and the integration of solar power as a sustainable source for educational institutions.
- For Electrical Engineering Students, continue applying technical knowledge through community-based projects to develop both practical and problem-solving skills aligned with industry standards.

Declarations

Source of Funding

This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The authors declare that they have no competing interests related to this work.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis, and manuscript writing equally.

Availability of data and materials

Authors are willing to share data and material on request.

Institutional Review Board Statement

This study was approved by the Institutional Review Board of Don Honorio Ventura State University, Philippines.

Informed Consent

All participants in this study voluntarily gave their informed consent prior to their involvement in the study.

Acknowledgments

The authors acknowledge all involved parties in this study.

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